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Help | Logout | Interrupt

Main Menu | Search Form | Posting Counts | Show S Numbers | Edit S Numbers | Preferences | Cases

Search Results -

Terms	Documents
L12 not l9	1

Database:
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Search: L13

Refine Search

Recall Text | Clear

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DATE: Friday, June 21, 2002 Printable Copy Create Case

Set Name side by side	**Query**	**Hit Count**	**Set Name** result set
	DB=USPT,PGPB,JPAB,EPAB,DWPI,TDBD; PLUR=YES; OP=ADJ		
L13	L12 not l9	1	L13
L12	L11 not l6	1	L12
L11	L10 and l4	4	L11
L10	L3 same (road or route or map)	501	L10
L9	L8 not l6	1	L9
L8	L7 and l2	4	L8
L7	l3 same l1	49	L7
L6	L5 and l4	5	L6
L5	L3 same (position or location)	14284	L5
L4	L2 and l1	532	L4
L3	(chang$3 or adjust$3 or mov$6) near shift$3	33896	L3
L2	(sens$3 or detect$3 or monitor$3) near transmission	19862	L2
L1	navigation or gps	406000	L1

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L6: Entry 4 of 5 File: USPT May 30, 2000

DOCUMENT-IDENTIFIER: US 6070118 A
TITLE: Transmission control system using road data to control the transmission

Brief Summary Paragraph Right (4):
In recent years, there is mounted on an ordinary vehicle a navigation system. This navigation system is constructed such that a map is held as electronic data in a memory medium such as CD-ROM whereas the position of the vehicle is located by the GPS (Global Positioning System) using an

Brief Summary Paragraph Right (5):
artificial satellite or the self-contained navigation (or dead reckoning method). These data are combined to output the present position or moving locus of the vehicle or a route to be followed, visually in a display unit such as the CRT, and to guide the running direction in voices.

Brief Summary Paragraph Right (6):
The electronic map to be used in the navigation system can be stored not only the data such as the layout of roads, the public facilities or the rivers but also the slopes of roads or the legal regulations on road traffics and further a variety of road data such as the coefficients of friction of road surfaces, as achieved by the actual runs. As a result, the data to be obtained by the navigation system can be used not only to guide the vehicle to a destination but also to control the engine, the transmission, the brake system and the body suspension system while the vehicle is running.

Brief Summary Paragraph Right (7):
One example is disclosed in JP-B-6-58141. The system, as disclosed, is constructed to change the shift pattern of the automatic transmission on the basis of the road data of a route to be followed, as achieved by the navigation system. For example: the shift is inhibited when a curve is detected ahead of the vehicle; the overdrive stage is inhibited when a mountainous region is detected; and a predetermined downshift is inhibited when the so-called "low-.mu. road" having a low coefficient of road surface friction is detected.

Brief Summary Paragraph Right (8):
In JP-A-5-322591, on the other hand, there is disclosed a system which is constructed to change a shift pattern of an automatic transmission in accordance with a road slope, as detected by the navigation system. Specifically, the control system for an automatic transmission, as disclosed in the Laid-Open, comprises: running state detecting means for detecting the running state of a vehicle; a navigation system for detecting the data of a road ahead of the vehicle, the running azimuth of the vehicle and the present position of the vehicle; and control means for changing the shift pattern (or the shift diagram) of the automatic transmission into such one for a slope as is adapted for the slope of the road.

Brief Summary Paragraph Right (10):
In the prior art, however, the system is constructed, as described above, such that the vehicle is controlled according to the individual road data on the route to be followed, as detected by the navigation system. As a result, if the road data requiring the so-called "special control" for changing the shift pattern for the upslope/downslope or the curved road are frequently detected, the hunting may occur to repeat the shift, and still the worse the drivability may be deteriorated. In the prior art, on the other hand, the shift pattern may be changed according to the actual

running state, or the running control characteristics may be set to predetermined ones by the manual operations. However, the prior art has taken no consideration into the control of the case in which that control interferes with the control based on the data obtained by the navigation system. As a result, the power performance of the vehicle may become different from the intention of the driver to cause a discomfort.

Drawing Description Paragraph Right (2):
FIG. 2 is a block diagram showing an example of the construction of a navigation system;

Detailed Description Paragraph Right (5):
The hydraulic control unit 12 is composed of a regulator valve for regulating the pressure, a shift valve for applying/releasing the lockup clutch or executing the speed change, and a plurality of solenoid valves (although not shown) for outputting signal pressures to those valves. There is further provided an automatic transmission electronic control unit (T-ECU) 13 for controlling the automatic transmission 2 indirectly by outputting electric signals to those solenoid valves. To the automatic transmission 2, moreover, there are attached sensors including a sensor for detecting the input RPM of the transmission, a sensor for detecting an output shaft RPM, and a sensor for detecting the oil temperature, although not especially shown.

Detailed Description Paragraph Right (11):
The following system is provided for improving the stability, drivability and power performance of the vehicle by feeding the data and the instruction signals to the aforementioned individual electronic control units 10 and 13. Specifically, there is provided a navigation system 20 which has a basic function to guide its carrying vehicle to a predetermined target. This navigation system 20 is equipped, as shown in FIG. 2, with an electronic control unit 21, a first data detecting unit 22, a second data detecting unit 23, a player 24, a display 25 and a speaker 26.

Detailed Description Paragraph Right (15):
The aforementioned first data detecting unit 22 is used to detect the present position of its carrying vehicle, the road situations and the distances from other vehicles by the self-contained navigation, and is composed of a geomagnetic sensor 30 for detecting the azimuth for driving the vehicle, a gyrocompass 31, and a steering sensor 32 for detecting the steering angle of the steering wheel.

Detailed Description Paragraph Right (18):
On the other hand, the second data detecting unit 23 detects the present position of its carrying vehicle, the road situations, the other vehicles, the blocks and the weather, and is composed of a GPS antenna 40 for receiving radio waves from an artificial satellite 39, an amplifier 41 connected with the GPS antenna 40, and a GPS receiver 42 connected with the amplifier 41.

Detailed Description Paragraph Right (20):
Moreover, the GPS receiver 42 and the ground data receiver 46 are so connected with the electronic control unit 21 as to effect the data communications so that the data, as detected by the second data detecting unit, are transferred to the electronic control unit 21.

Detailed Description Paragraph Right (23):
In the navigation system 20 described above, the data of the roads to be followed, as detected by the first data detecting unit 22, the data of the roads to be followed, as detected by the second data detecting unit 23, and the map data, as stored in the data recording medium 27, are synthetically compared or evaluated to decide the road situations of or around the present position of the vehicle on the route being followed.

Detailed Description Paragraph Right (29):
The control system having the construction thus far described controls the automatic transmission 2 on the basis of the road data, as obtained from the aforementioned navigation system 20 or by detecting the actual running states. Here will be described examples of the control.

Detailed Description Paragraph Right (30):

FIG. 3 shows an example of the control at the starting time on a curved road. At first Step 1: the present position of the vehicle is located by the navigation system 20; the present position and the coming road situations are specified; and the control of the automatic transmission 2 is executed by the basic pattern. Here, the present position of the vehicle can be located, as customary, by the aforementioned dead reckoning navigation or GPS. Moreover, the road situations can be specified on the basis of the data, as stored in the navigation system 20, and the data as obtained from the aforementioned ground data transmission system 43. Incidentally, the road ahead of the present position can be specified by inputting the destination to set the route to be followed. Alternatively, the coming road can be judged from either the route followed just before or the map data. Moreover, the basic shift pattern can be executed as the shift patter by reading the pattern stored as the shift diagram, for example.

Detailed Description Paragraph Right (40):
Here will be described an example of the control in which the vehicle is braked on a curved road. This control example is shown in FIG. 4. At first, the location of the present position, the specification of the coming road situations, and the control by the basic shift pattern are executed (at Step 11) as at Step 1 in the aforementioned control of FIG. 3. It is then decided (at Step 12) from the road data of the navigation system 20 whether or not a corner is in front of the vehicle, or whether or not the vehicle is cornering. Simultaneously with this, the radius of the corner is detected. If the answer of Step 12 is "YES", it is decided (at Step 13) whether or not the braking operation has been conducted just before the corner, or whether or not the accelerator pedal is returned during the cornering. These decisions can be executed by the predetermined control unit such as the automatic transmission electronic control unit 13. Incidentally, at this Step 13, the magnitude of the braking force at the braking time is also detected. This detection can be decided on the basis of the changing rate of the vehicle speed, that is, the deceleration.

Detailed Description Paragraph Right (48):
Here will be described the control for an automobile dedicated road. FIG. 5 shows an example of the control, in which a control similar to that of Step 1 of FIG. 3 is executed (at Step 21). Next, it is decided (at Step 22) whether or not the vehicle enters an expressway. If the answer of Step 22 is "YES", it is decided (at Step 23) whether or not the vehicle is to start from the ramp way of the expressway such as the tollgate, the ticket inspection gate or the service area. These decisions can be executed by the navigation system 20.

Detailed Description Paragraph Right (57):
Next, a control example, in which the coefficient of friction of the road surface is small, will be described with reference to FIG. 6. In FIG. 6, controls similar to those of Step 1 of FIG. 3 are executed at Step 41. By the navigation system 20, moreover, it is decided (at Step 42) from the set content of a destination whether or not the vehicle is running in a cold zone. If the answer of Step 42 is "YES", it is decided (at Step 43) whether or not the ambient temperature is no more than a predetermined value stored in advance, and it is decided on the basis of a calendar stored as electronic data whether or not it is in winter.

Detailed Description Paragraph Right (60):
It is then decided (at Step 45) whether or not the road has a low coefficient of friction, that is, a frozen state. This decision can be made on the basis of the data stored in advance in the navigation system 20, or the renewable data, or by the anti-lock brake system 50 or the vehicle stability control system 70. If the answer of Step 45 is "YES", the shift pattern for the cold zone is changed to one for the snow mode (or the shift pattern for the low-friction coefficient road) (at Step 46). Incidentally, if it is detected at Step 45 that the road is not the low-friction coefficient road, the control is made as it is with the cold zone shift pattern, and the control routine is returned.

Detailed Description Paragraph Right (63):
A control example for the vehicle to run in a urban area will be described with reference to FIG. 7. In FIG. 7, at first, controls similar to those of Step 1 of FIG. 3 are executed at Step 51. Next, it is decided (at Step 52) whether or not the vehicle runs in the urban area or whether or not the vehicle has already been running in the

urban areas (or residential district). This decision can be executed on the basis of either the detection result of the present position by the navigation system 20 or the road data. If this answer of Step 52 is "YES", the basic shift pattern is changed to one for the urban area, by which the automatic transmission 2 is controlled (at Step 53), and then the control routine is returned. Here, the shift pattern for the urban area is one, in which the region of the gear stage on a higher speed side having a low gear ratio is expanded to a lower speed side to a larger throttle opening .theta. side.

Detailed Description Paragraph Right (67):
In FIG. 8, the location of the present position and the situation of the present position and the coming road situations are executed by the navigation system 20 (at Step 61). These controls are similar to the aforementioned ones of Step 1 shown in FIG. 3. Here, the coming road is either a route to be followed to the destination, as inputted to the navigation system 20, or a forward road to be estimated on the basis of the running history to that point.

Detailed Description Paragraph Right (68):
When the coming road situations are thus specified, it is decided (at Step 62) whether or not a corner (or a curved road) is on a downslope in front of the vehicle. Here, the "front" covers the range which extends from the present position on the route to be followed, as detected by the navigation system 20. Moreover, the "curve" in the present invention covers both the case, in which the road itself is curved (as at an intersection or an ordinary curve), and the curving on the basis of the route to be followed.

Detailed Description Paragraph Right (71):
When the vehicle advances to a downslope, the downslope control is executed. When a corner is passed or when the downslope ends, the downslope control is ended, and the basic shift pattern is restored (at Step 64). The decision for executing these controls of Step 64 can be made with either the road data, as achieved by the navigation system 20, or the acceleration/or deceleration as detected on the basis of the vehicle speed.

Detailed Description Paragraph Right (83):
It is then decided whether or not a corner is ahead of the vehicle or whether or not the vehicle is cornering (at Step 72). This decision can be made by the navigation system 20, and the present cornering can be decided on the basis of the input signal coming from the yawing rate sensor or the steering sensor. If this answer of Step 72 is "YES", it is decided (at Step 73) whether or not the brake switch has been turned ON from OFF, that is, whether or not a braking has been executed. This decision can be made on the basis of the signal coming from the brake switch, as inputted to the automatic transmission electronic control unit 13, for example.

Detailed Description Paragraph Right (85):
If the answer of Step 72 is "NO", on the other hand, it is decided (at Step 75) whether or not the vehicle is at the corner exit. This decision can be made by the navigation system 20. If the answer of Step 75 is "YES", the running resistance is reduced to allow an upshift (at Step 76). This control can be executed either by changing the shift diagram or resetting a control flag for inhibiting the shift. The control routine is then returned. If the answer of Step 73 or Step 75 is "NO", the control by the unchanged shift pattern (i.e., the shift pattern for the downslope control) is executed, and the control routine is returned. Incidentally, the control, as shown in FIG. 10, can be executed not only on a downslope but also on an upslope.

Detailed Description Paragraph Right (90):
FIG. 11 shows a control example for changing a downslope control in accordance with a straight road between corners or downslopes. At first Step 81, the present position is located, and the road situations ahead of the present position are specified. These operations can be performed as at Step 61 shown in FIG. 8. Next, on the basis of the road situations specified at Step 81, it is decided (at Step 82) whether or not a corner exit is ahead of the vehicle. If the answer of Step 82 is "YES", the distance to a straight road to a next corner or a next downslope is calculated, and a threshold value for deciding the execution of the downslope control on the basis of the distance of the straight road is calculated (at Step 83). The distance of the straight road can

be calculated on the basis of the road data stored in the navigation system 20. Moreover, the calculation of the threshold value, as based upon the former calculation, can be executed by storing the relation of the two in advance as a map and by reading the threshold value corresponding to the calculated distance of the straight road. Incidentally, the threshold value is set, for example, to the higher value (or gradient) for the longer distance of the straight road. In short, the gradient for the downslope control to be executed becomes the larger for the longer straight road.

Detailed Description Paragraph Right (95):
Here will be described a control example in which the continuation or return (or quit) of the upslope/downslope control is decided on the basis of the time or distance from the present position in place of the control for deciding the execution/inexecution of the downslope control from the distance from the aforementioned corner exit to the next corner or the downslope. FIG. 12 shows a control example on a downslope. First of all, the vehicle is braked, and it is decided (at Step 91) whether or not the distance or time to the downslope is less than a reference value. This decision can be made on the basis of the signal coming from the brake switch, as inputted to the automatic transmission electronic control unit 13, and the road data obtained by the navigation system 20.

Detailed Description Paragraph Right (99):
The aforementioned control shown in FIG. 12 can also be applied to a control on an upslope, as exemplified in FIG. 13. First of all, it is decided (at Step 101) whether or not the vehicle is running at the 1st to 3rd speeds after the power-ON downshift and whether or not the time or distance to the upslope is less than a predetermined value. These decisions can be done as at Step 91 of FIG. 12 by the navigation system 20 and the automatic transmission electronic control unit 13.

Detailed Description Paragraph Right (112):
First of all, an decision control of a winding road will be described with reference to FIG. 16. If the road being followed is not a winding road, the terminal point of a straight portion, from which the winding road is possibly begun, that is, the starting point of a curved portion is set as the initial point for searching the winding road. Specifically, for a point P(n) (n=1, 2, - - -) ahead of the present position on the basis of the road data of the navigation system 20, the end point P(iws) is determined as iws if the vehicle is running straight. If the vehicle is running on a curve, the end point of a next straight portion P(iws)is determined as iws (at Step 131).

Detailed Description Paragraph Right (120):
FIG. 17 shows an example of the shift control on the winding road thus searched. First of all, it is decided (at Step 151) whether or not the vehicle is running on the winding road. For this, whether or not the vehicle is located in the winding section on the map, as decided as above, may be decided by the navigation system 20. If this answer of Step 151 is "YES", this routine is returned. If the answer is "NO", on the contrary, a coming winding road is searched (at Step 152). This is executed by the aforementioned routine shown in FIG. 16.

Detailed Description Paragraph Right (125):
FIG. 18 shows a control example, in which the present position is located, and coming road situations are specified (at Step 161). These operations can be executed as at Step 61 in FIG. 8. Next, it is decided (at Step 162) whether or not the 4th speed (i.e., the highest gear stage or the overdrive stage) by the downslope control is inhibited (at Step 162). In this downslope control, when a downslope is detected by the navigation system 20, the shift pattern is changed to one for the downslope so that shift is executed on the basis of the downslope shift pattern. Alternatively, a downslope is detected on the basis of the acceleration to change the shift pattern to one for the downslope so that the shift is executed on the basis of the downslope shift pattern. This downslope shift pattern has a content to inhibit the highest gear stage so that a gear stage on a lower speed side for effecting the engine brake may be set easily.

Detailed Description Paragraph Right (126):
If the answer of Step 162 is "YES", it is decided (at Step 163) whether or not a flat road is in front. This decision can be made on the basis of the road data of the

navigation system 20. If the answer of Step 163 is "YES", the running distance or time from the present downslope to a next downslope is calculated (at Step 164), and it is decided (at Step 165) whether or not the calculation result is less than a predetermined value stored in advance.

Detailed Description Paragraph Right (138):
Next, it is decided (at Step 192) whether or not the 4th speed is inhibited by the downslope control. If this answer of Step 192 is "YES", it is decided (at Step 193) whether or not a corner exit is approaching. This decision can be made by the navigation system 20.

Detailed Description Paragraph Right (143):
The road data can also be achieved either by the navigation system 20, as described hereinbefore, or from the actual running state, as described with reference to FIG. 14. As a result, while both the shift controls, as based upon the data achieved by the navigation system 20 and upon the actual run, are being executed, either of them is adopted according to the difference between the gear stages decided by the individual controls.

Detailed Description Paragraph Right (144):
FIG. 22 shows an example of the control. The upslope/downslope control is executed on the basis of the running state such as the actual acceleration, and the shift control of the automatic transmission 2 is executed (at Step 201) on the basis of the road data achieved by the navigation system 20. The latter control is a cooperative control between the navigation system 20 and the automatic transmission 2.

Detailed Description Paragraph Right (145):
It is decided at Step 202 whether or not both the controls are being executed. If this answer of Step 202 is "YES", it is decided (at Step 203) whether or not a gear stage Ssl by the upslope/downslope control is at a lower speed than the gear stage Snv, as decided by the cooperative control between the navigation system 20 and the automatic transmission 2.

Detailed Description Paragraph Right (146):
If this answer of Step 203 is "YES", the shift control by the upslope/downslope control is executed. Specifically, the upslope/downslope is detected on the actual running state so that a shift, as based on a shift pattern for accordingly easily setting a gear stage on a lower speed side, is executed (at Step 204). On the contrary, if the answer of Step 203 is "NO", that is, if the gear stages by the two controls are identical or if the gear stage by the shift control by the navigation system 20 is on a lower speed side, the shift control by the cooperative control between the navigation system 20 and the automatic transmission 2 is executed (at Step 205). Incidentally, if the answer of Step 202 is "NO", the shift control being executed at that instant is executed as it is (at Step 206). Thanks to this control, the gear stage on a lower speed side is preferentially selected so that the running can be effected with an excellent power performance. As a result, the aforementioned Step 203 corresponds to comparison means in claim 10, and Steps 204 and 205 correspond to shift instructing means.

Detailed Description Paragraph Right (147):
Incidentally, while both the shift control for determining the gear stage by the actual running state and the road data obtained by the running and the cooperative control of the navigation system 20 and the automatic transmission 2 are being executed, it is arbitrary to additionally select either of the shift controls simply. FIG. 23 shows this example, in which if the aforementioned answer of Step 202 of FIG. 22 is "YES", the routine instantly advances to Step 205 to execute the shift control by the cooperative control of the navigation system 20 and the automatic transmission 2. If the answer of Step 202 is "NO", on the contrary, the routine advances to Step 206, at which the shift control being executed at that instant is continued.

Detailed Description Paragraph Right (148):
According to this control shown in FIG. 23, therefore, the gear stage is determined on the basis of the road data obtained by the navigation system 20. Specifically, the gear stage is set according to the road situations ahead of the route to be followed, so that the delay in the shift control is avoided to improve the drivability.

Detailed Description Paragraph Right (149):
Here will be described another example of the shift control which can be executed by the control system of the present invention. The aforementioned navigation system 20 can be stored in advance with data other than those such as the slope and curve of a road or a discrimination between an expressway or an ordinary way and can also be supplied from the outside by a communication system. The control, as shown in FIG. 24, is exemplified by the shift control which is based on such various road data.

Detailed Description Paragraph Right (150):
In FIG. 24, control operations similar to those of Step 61 of FIG. 8 are executed at Step 211. On the basis of the road data by the navigation system 20, moreover, it is decided (at Step 212) whether or not the route to be followed by the vehicle contains a specific area such as the entrance/exit of an expressway, a junction of the expressway, a mountainous region, an unpaved road a farm road, a forestry road, a riverbed road or a gravel road. If the answer of Step 212 is "YES", the shift pattern is changed (at Step 213) to one for the slope/curve, which is liable to use a gear stage on a lower speed side than that of the slope shift pattern.

Detailed Description Paragraph Right (154):
shift pattern. Specifically, at Step 221, control operations similar to those of Step 61 of FIG. 8 are executed, and the automatic transmission 2 is controlled by the basic shift pattern. It is then decided (at Step 222) whether or not a slope is in the route to be followed. If the answer of Step 222 is "YES", there are set the timings for changing the basic shift pattern to the slope shift pattern and vice versa on the basis of the slope situations, as detected by the navigation system 20, i.e., the gradient of the slope. Even in a series of slopes, the section, in which the slope gradient is larger than a predetermined value stored in advance in the navigation system 20, is controlled by the slope shift pattern, and the section having a smaller gradient than a predetermined value is controlled by the basic shift pattern.

Detailed Description Paragraph Right (158):
Next, the present position is located by the navigation system 20, and it is decided (at Step 232) whether or not the vehicle is ascending or descending a slope with the 4th speed being inhibited. If the answer of Step 232 is "YES", it is decided (at Step 233) whether or not a change is in the gradient direction of a slope in front, such as a change from an upslope to a downslope or a change from a downslope to an upslope. If the answer of Step 233 is "YES", the slope shift pattern is retained as it is, and the control for inhibiting the 4th speed is continued (at Step 234). After this, the control routine is returned.

Detailed Description Paragraph Right (161):
The control system of the present invention can perform controls in cooperation with a cruise control system for keeping a preset vehicle speed. This cruise control system sets the vehicle speed, when the switch is operated while the vehicle is running, so that the engine electronic control unit 10 controls the opening of the electronic throttle valve 7 so as to keep the vehicle speed. This control is effected by detecting the actual vehicle speed and by controlling the throttle opening to eliminate the difference from the set vehicle speed, and it may be delayed. If the running resistance is high at a corner, for example, the opening of the electronic throttle valve 7 is increased after the vehicle speed goes down, or the downshift of the automatic transmission 2 is instructed. In the case of a corner on a downslope, alternatively, the vehicle speed exceeds the preset value so that the vehicle is decelerated after the transverse acceleration (or transverse G) has considerably risen. According to the navigation system 20, on the contrary, the coming road situations can be detected so that the vehicle speed by the cruise control can be changed according to the road situations, as detected by the navigation system 20, to improve the drivability. An example is shown in FIG. 27, in which it is decided at first at Step 241 whether or not the vehicle is under a cruise control (C/C control). If this answer of Step 241 is "NO", the control is skipped out from this routine. If the vehicle is under the cruise control, on the other hand, the routine advances to Step 242, at which it is decided whether or not the travers acceleration (transverse G) is less than a target valueother hand, the routine advances to Step 242, a when the vehicle runs at the preset speed around the coming corner.

Detailed Description Paragraph Right (165):
Incidentally, here will be described a control example for preventing the busy shifting when the vehicle is running toward a corner. In FIG. 28, at first, it is decided at Step 251 whether or not the condition for inhibiting an upshift is satisfied. This is a step for deciding whether or not a condition similar to that for executing the upslope/downslope control is satisfied, and this decision is made on whether or not the condition for inhibiting the 4th speed, for example, is satisfied on the basis on the actual running state or the road data obtained from the navigation system 20. If this answer of Step 251 is "NO", the control is skipped out from this routine. If the answer is "YES", on the contrary, it is decided (at Step 252) whether or not the downshift executing condition is satisfied.

Detailed Description Paragraph Right (173):
Here will be described a control example at a corner having a low coefficient (.mu.) of friction of the road surface. At first in FIG. 31, it is decided (at Step 281) whether or not the vehicle is running in a cold district. Here, this cold district is a region, in which the friction coefficient of the road surface is lowered by the snowfall, and is exemplified by a road near a specific mountain or a specific district, as stored in advance as the road data of the navigation system 20. If this answer of Step 281 is "YES", it is decided (at Step 282) whether or not it is in a specific season such as winter. At this Step 282, it is decided on the basis of the calendar data stored in the navigation system 20 whether or not it is a snowing season or a snow lying season in the aforementioned cold district.

Detailed Description Paragraph Right (177):
As has been described hereinbefore, the cruise control system performs the control to keep the preset vehicle speed. If a device for detecting a vehicle ahead such as a laser radar is connected with the cruise control system, the vehicle can accompany a vehicle ahead while keeping the distance inbetween at a predetermined value. A control example for executing the so-called "inter-vehicle distance control" or "accompany control" and the shift control, as based on the road data obtained from the navigation system 20, together will be described with reference to FIG. 32.

Detailed Description Paragraph Right (178):
First of all, it is decided at Step 291 whether or not the vehicle is under the cruise control (or C/C) for keeping the distance between vehicles. This decision can be made on the basis of an operation signal of the cruise control system. If this answer is "YES", the distance to a coming corner, a cornering radius R and a target cornering speed are calculated (at Step 292) on the basis of the road data which are obtained by the navigation system 20. Next, a target deceleration is calculated (at Step 293) from the vehicle speed at present and the target cornering speed (or the cornering radius R) at the corner. In this case, the target deceleration may be calculated by using the set vehicle speed in the cruise control in place of the present vehicle speed.

Detailed Description Paragraph Right (184):
Next, it is decided (at Step 302) whether or not a reference point for calculating the altitude has been passed. This reference point is a point within a predetermined distance before a high-level branching point, if the level of a high-level road such as an urban motorway is to be decided, and a point at a definite level if the altitude is to be simply calculated. Here, the point having a definite level is exemplified by a very coarse altitude point in the navigation system 20 or an OFF point of the ignition switch, as located at an altitude calculated on the basis of the data set by a car dealer.

Detailed Description Paragraph Right (188):
Here will be described an example of the control for discriminating the high level road such as of an urban motorway by making use of the altitude difference .DELTA.h thus determined. First of all, as shown in FIG. 34, it is decided (at Step 311) whether or not the vehicle has approached to the upslope at the entrance or the downslope at the exit of an motorway. This decision can be made on the basis of the road data of the navigation system 20. The control is skipped out from this routine, if the answer of Step 311 is "NO", but the altitude difference .DELTA.h is calculated (at Step 312) if the answer is "YES". The routine for calculating the altitude difference .DELTA.h has already been described with reference to FIG. 33.

Detailed Description Paragraph Right (190):
According to this control shown in FIG. 34, not only the road data by the navigation system 20 but also the road data as a result of the actual run can be achieved so that the shift control of the automatic transmission 2, as based on the road data, can be more accurately executed. In other words, the upslope/downslope at the entrance/exit of the high level road can be executed without any delay to improve the acceleration at the time of entering into the motorway or high-level road and the deceleration at the time of leaving the motorway.

Detailed Description Paragraph Right (191):
FIG. 35 shows a control routine for calculating the altitude of the present position. In FIG. 35, at first, it is decided (at Step 321) whether or not a reception is made from the GPS (Global Positioning System). If this answer of Step 321 is "NO", the control is skipped out from this routine. If the answer of Step 321 is "YES", on the contrary, the altitude is calculated (at Step 322). Specifically, the altitude is calculated by adding the altitude difference .DELTA.h, as calculated in the aforementioned control of FIG. 33, to the altitude h of the reference point. Next, the present position is calculated (at Step 323) from the data of GPS and the altitude data, as calculated at Step 322.

Detailed Description Paragraph Right (192):
According to the control of FIG. 35, therefore, the information content for calculating the present position increases to improve the calculation accuracy of the present position. By the altitude data thus obtained, moreover, the error of the present position by the navigation system 20 can also be corrected. In this case, the error correction may be made by detecting the point, in which the altitude or slope highly changes, and by comparing the detected point with the present position. Especially in the case of a map matching, the changing point can be detected even on a straight road so that the map matching can be easy and accurate. According to the control of FIG. 35, moreover, even if the receiving state from the GPS is poor or even if the number of receiving satellites is small, the present position is calculated from the data, as based on the actual run result, so that the reliability of the shift control, as based on the navigation system 20 and the road data, is improved better.

Detailed Description Paragraph Right (193):
Here will be described an example in which the road data obtained by the navigation system 20 are used for controlling the oil temperature of the automatic transmission 2. FIG. 36 shows one example, in which it is decided (at Step 331) on the basis of the road data of the navigation system 20 whether or not an upslope is continued in front longer than a predetermined distance. If this answer of Step 331 is "NO", the control is skipped out from this routine. If the answer is "YES", on the contrary, it is decided (at Step 332) whether or not the oil temperature Tat of the automatic transmission 2 is higher than a predetermined value and has a tendency to rise (.DELTA.Tat>0). The control is skipped out from this routine, if the answer of Step 332 is "NO", but the suppressive control of the oil temperature of the automatic transmission 2 is executed (at Step 333) if the answer is "YES".

CLAIMS:

11. A control system for a transmission, comprising:

shift control means for outputting a shift instruction on the basis of a predetermined shift pattern;

road data detecting means for detecting the road data of a route to be followed by a vehicle;

brake detecting means for detecting the execution of a wheel braking operation in said vehicle;

shift inhibiting means for inhibiting the shift in said transmission when it is detected by said brake detecting means that the route to be followed by said vehicle is a curved road and when the wheel braking operation is detected by said brake detecting means; and

shift inhibition releasing means for allowing the shift in said transmission when the end of the curved road is detected by said road data detecting means.

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L6: Entry 2 of 5 File: USPT Aug 21, 2001

DOCUMENT-IDENTIFIER: US 6278928 B1
TITLE: Transmission control device responsive to road information

Abstract Paragraph Left (1):
A vehicle control device controls an automatic transmission by utilizing road information stored in a navigation system unit. In response to the road information stored in a data memory, the upper-limit of a shiftable transmission speed range is determined, thereby allowing shift-change only within the restricted transmission range. The actual down-shift is carried out after confirming a decelerating operation by the driver, such as release of the accelerator pedal, thereby providing favorable transmission control in conformity with the driver's intention.

Brief Summary Paragraph Right (2):
The prior art for controlling transmission stages by utilizing road data stored in a navigation system mounted on a vehicle includes Japanese patent publication No. 6-272753 and Japanese patent laid-open publication No.7-234991 which have proposed a control device that controls the transmission stage based on various items of information, including vehicle speed variation and degree of accelerator opening, that can be detected by sensors, and map information read out from the navigation system. Such a device provides the vehicle with an optimum transmission stage in conformity to the varying drive conditions.

Brief Summary Paragraph Right (3):
With the above-described prior art transmission control devices, road data is obtained from the navigation system in order to determine a transmission stage in conformity with the condition of the road on which the vehicle is now running. However, all information used in such prior art control systems merely indicates the current drive conditions. With the prior art systems, it is not possible to control the transmission in anticipation of future changes in the drive conditions.

Brief Summary Paragraph Right (9):
To achieve the above object, the present invention provides a vehicle control device for a vehicle including means for obtaining road information, current position sensor means for detecting an on-road current position, means for determining a control parameter for the vehicle's automatic transmission in accordance with the detected current position and the obtained road information, deceleration sensor means for detecting a driver's decelerating operation, and execution means for executing control of the determined control parameter when the driver's decelerating operation is detected by said deceleration sensor means.

Detailed Description Paragraph Right (3):
The vehicle control device 1 of this invention includes a navigation system 10, an automatic transmission 41, an A/T mode select unit 20 and a vehicle condition sensor 30. Navigation system 10 has a navigation processing unit 11, a data memory unit 12 that stores road information, a current position sensor 13, a select means or a control release switch 14, a communication unit 15, an input unit 16, a display unit 17, a voice input unit 18 and a voice output unit 19.

Detailed Description Paragraph Right (4):
Navigation processing unit 11 has a central processing unit (CPU) 111 that operates in response to the input information to perform various data processing operations and output the results. To CPU 111 are connected ROM 112 and RAM 113 through data bus

lines. ROM 112 is a read only memory storing programs for searching of a drive route to the destination, drive guidance along the drive route, and determination of a certain section on the drive route, for example. RAM 113 is a random access memory to be used as a working memory when CPU 111 performs a data processing operation.

Detailed Description Paragraph Right (6):
Among information stored in these files, the files respectively storing intersection data, node data and road data are used in main for route searching by the navigation system. These files store data regarding road width, slope or gradient, road surface condition, radius of curvature, intersection, T-shaped intersections, number of road lanes, lane-merging points, approach to a corner, railway crossings, exit ramps of expressways, tollgates, points where the road width narrows, downhill roads, uphill roads, latitude and longitude indicating absolute coordinates, altitude of absolute coordinates, absolute position and altitude of nodes on roads, etc. Road information comprises the above-described data for the detected current vehicle position, and comprises in main information for the road ahead of the current position in the direction of driving. For example, such information includes intersections positioned forward on the drive route, corners, nodes and radii of curvature in predetermined sections, distance from the current position to a predetermined point such as an intersection or to a predetermined section, etc. The road information also includes various road conditions as detected by respective sensors and obtained through communication means, etc.

Detailed Description Paragraph Right (8):
Current position sensor 13 has a GPS receiver 131, a terrestrial magnetism sensor 132, a distance sensor 133, a steering sensor 134, a beacon sensor 135 and a gyro-magnetic sensor 136. GPS receiver 131 receives radio waves from earth satellites to determine the vehicle position. Terrestrial magnetism sensor 132 detects terrestrial magnetism to determine the direction in which the vehicle is advancing. Distance sensor 133 may be a measuring device of a type wherein the number of wheel rotations is detected followed by calculation or another type wherein acceleration is detected followed by integration twice. Steering sensor 134 is typically an optical rotation sensor or a rotation-resistant volume mounted on a rotating steering member, but may be a steering angle sensor mounted to the wheel. Beacon sensor 135 receives positional information from beacons arranged along the roads. Gyro-magnetic sensor 136 may be a gas-rate or vibration type gyro-magnetic sensor that detects a turning angle velocity of the vehicle followed by integration to determine the vehicle running direction.

Detailed Description Paragraph Right (9):
GPS receiver 131 and beacon sensor 135 alone can serve to measure the vehicle position. Further, the absolute position of the vehicle may be determined by combination of a distance detected by distance sensor 133 and a direction detected by terrestrial magnetism sensor 132 and/or gyromagnetic sensor 136, or by combination of a distance detected by distance sensor 133 and a steering angle detected by steering sensor 134.

Detailed Description Paragraph Right (14):
With the above-described arrangement, the navigation system operates to provide road information for the area around the vehicle current position to the driver, thereby guiding the driver along a specific route to the destination. More particularly, when the destination is input through input device 16, navigation processing unit 11 operates to selectively determine a recommended drive route to the destination, based on the vehicle current position detected by current position sensor 13 and the road information read out from data memory unit 12. The drive route is output to display unit 17. The drive route shown on display unit 17 cooperates with the voice information outputted through voice output unit 19 to lead the driver to the destination. When no destination is input, navigation processing unit 11 outputs only the road information for the area around the vehicle current position to display unit 17.

Detailed Description Paragraph Right (15):
In the above-described navigation system 10, current position sensor 13 comprises the current position sensor means, and data memory unit 12 and navigation processing unit 11 cooperate with each other to constitute the road information obtaining means. A specific point positioned forward of the vehicle current position in the driving

direction is determined by navigation processing unit 11, based on the current position and the driving direction of the vehicle, as determined by current position sensor 13, and the road information stored in data memory unit 12. The distance calculating means is constituted by current position sensor 13, data memory unit 12 and navigation processing unit 11.

Detailed Description Paragraph Right (19):
The drive route may have been programmed in the navigation system. When no drive route has been programmed in the navigation system the drive route may be assumed to go straight.

Detailed Description Paragraph Right (20):
The control parameter to be controlled in this embodiment is the gear ratio of transmission, more particularly transmission stages. The above-described navigation processing unit 11 determines a specific single transmission stage or a restricted range of stages within which the transmission is shiftable, whereby a command signal indicating the specific stage or the upper limit stage within the restricted shiftable range is output to the automatic transmission as described later. The navigation system 10 determines the actual transmission stage in response to the command signal, even if another stage is selected under the normal transmission control governed by A/T ECU 40. Thus, navigation processing unit 11 constitutes the control parameter determining means in this embodiment.

Detailed Description Paragraph Right (22):
A decelerating operation is detected as at least one of the brake ON/OFF indicating signal, accelerator's opening degree indicating signal and blinker ON/OFF indicating signal received by the navigation processing unit 11. The vehicle speed V detected by vehicle speed sensor 31 is supplied both to navigation processing unit 11 and an electric control circuit 40 to be described later. The throttle opening degree detected by throttle opening sensor 35 is supplied to electric control circuit 40.

Detailed Description Paragraph Right (30):
Navigation system unit 10 and A/T ECU 40 are connected with each other by communication lines for mutual communication.

Detailed Description Paragraph Right (33):
The transmission maps have been prepared separately for a normal mode and a sport mode, one of which is automatically selected in response to the transmission mode indicating signal supplied from navigation processing unit 11. The transmission mode may also be changed manually by the driver's operation of AT mode selecting unit 20.

Detailed Description Paragraph Right (37):
When the shift lever is in the drive position, any one of 1st to 5th gear speeds of the transmission can be selected. One of 1st to 3rd gear speeds in transmission stages is selectable in the third speed position. Either of 1st and 2nd gear speeds in the second speed position. In the low speed position only 1st gear speed is applicable. In this embodiment, navigation system 10 provides the automatic transmission control operation when the shift lever 21 is held at the drive position. For example, when A/T ECU 40 determines 4th gear speed but navigation system 11 commands that the transmission stage should be 3rd gear speed, then the drive signal commanding 3rd gear speed is supplied. When A/T ECU 40 determines 4th gear speed but navigation system 11 commands that the upper limit of the transmission stages should be 3rd gear speed, then the drive signal ranges 1st to 3rd and does not command 4th. The drive signal is supplied to actuator 41 which sets the actual transmission ratio.

Detailed Description Paragraph Right (38):
As described above, navigation processing unit 11 and the automatic transmission cooperate with each other to constitute the control executing means of this embodiment. The shift position and the transmission mode signals are supplied via A/T ECU 40 to navigation processing unit 11. In a modified embodiment, navigation processing unit 11 stores in advance transmission maps of A/T ECU 40, in which case navigation processing unit 11 determines an actual transmission stage within a restricted range, with reference to the transmission map, which is then output to A/T ECU 40.

Detailed Description Paragraph Right (40):
With the above-described arrangement, the transmission speed control (referred to as navigation AT control) is conducted based on the road information in the navigation system as follows.

Detailed Description Paragraph Right (41):
In this embodiment navigation processing unit 11 is the specific position determining means. Navigation processing unit 11 operates, in response to the road information stored in data memory 12, to determine a specific position forward in the vehicle drive direction on a scheduled drive route. It also acts as the distance calculating means to calculate a distance (d) from the current position to the specific position.

Detailed Description Paragraph Right (42):
Further, navigation processing unit 11 acts as the deceleration inference means to infer a need for deceleration, in accordance with the current vehicle speed and the road information at or around the specific position. When there is a need for deceleration, navigation processing unit 11 determines a specific one of the transmission stages for the necessary deceleration, in accordance with the distance (d), the road information at or around the specific position, the current vehicle speed and the current transmission stage. In this embodiment, data used for vehicle control is the road information, and data from navigation processing unit 11 is the road data. Accordingly, the road data and the road information may be at least partly identical. The road information may be prepared and extracted from the road data.

Detailed Description Paragraph Right (43):
In response to detection of release of the accelerator pedal, brake pedal operation and turning on the blinker, which are deemed symbolic of the driver's intention to decelerate, navigation processing unit 11 operates to determine a desired transmission stage, which is output to A/T ECU 40 of the automatic transmission. A/T ECU 40 preferentially adopts the selected transmission stage supplied from navigation processing unit 11 and, in turn, supplies a corresponding drive signal to actuator 42 for shift change to the selected transmission stage. Thus, navigation processing unit 11 and A/T ECU 40 cooperate with each other to constitute the executing means.

Detailed Description Paragraph Right (44):
Detailed explanation of the control operation conducted by navigation processing unit 11, as the control parameter determining means, will be given hereinbelow with reference to the flowchart of FIG. 3. The flowchart of FIG. 3 shows the control operation when a curve or corner of the road is detected as a specific point, and the road information to be acquired comprises a radius of curvature, continuity of the curve, radius variation in the curve and length of the curve.

Detailed Description Paragraph Right (45):
First, navigation processing unit 11 acquires the current position of the vehicle 2 and the road data forward in the drive direction, at step S101. The road data forward in the drive direction includes a classification or type of the road, shape of the road ahead, and coordinate data of the respective nodes N1-Nn ahead of the current vehicle position, such as shown in FIG. 4.

Detailed Description Paragraph Right (47):
Next, the drive condition corresponding to vehicle information is acquired, at step S103. The vehicle information includes a vehicle speed V, a degree of opening of the accelerator .alpha. and a brake signal. Based on the vehicle information and the road condition previously obtained at S102, navigation processing unit 11 determines if the vehicle speed should be decreased, at step S104.

Detailed Description Paragraph Right (48):
In determining a need for deceleration, navigation processing unit 11 first determines an appropriate speed at which the vehicle can drive along the curve with good stability, with reference to the detected nature or shape of the curve. From the appropriate speed and the distance (d) to the curve is determined the necessary deceleration which, in turn, determines the degree of slowdown and necessity for a down-shift.

Detailed Description Paragraph Right (56):

First, navigation processing unit 11 acquires the current position data, data of the road forward in the drive direction and other necessary data, at step S201. The forward road data includes the road type, the forward road shape, the number of roads crossing at the intersection, the width of the crossing roads, the number of lanes, etc.

Detailed Description Paragraph Right (67):
Navigation processing unit 11 first acquires the current position data and the road data regarding the freeway road, at step S301. The road data regarding the freeway forward of the current position includes the road classification, position of the rampway, the shape of the road ahead, the width of the road and the number of lanes.

Detailed Description Paragraph Right (68):
From the data obtained at S301, position of the ramp to enter, entry to the rampway and a predetermined control section to the entrance to the rampway are confirmed at step S302. At this step a distance (d) from the current position to the entrance to the rampway, which is a specific position in this embodiment, is also calculated. The shift-change control operation is carried out when the vehicle is within the control section which is determined in advance to extend over a predetermined distance in advance of the entrance to the rampway.

Detailed Description Paragraph Right (70):
When the current position is within the control section and the vehicle speed is lower than a predetermined speed, then it is inferred in the affirmative that deceleration is needed, in which case the procedure enters an overdrive control routine for compulsorily making overdrive inoperative in the automatic transmission. The overdrive control is carried out after confirming the driver's decelerating operation at steps S305 and S306. More particularly, when a drive route has already been determined by navigation system 10 so that a rampway to be entered has also been determined, it is determined at S305 if the driver has released the accelerator pedal. When the accelerator pedal is still depressed which suggests that the driver does not intend to slow down, it is inferred at S308 that it is not necessary to cancel the overdrive, in which case the routine returns to the beginning for resuming S301-S304.

Detailed Description Paragraph Right (76):
Navigation processing unit 11 first obtains the current position data and the road data regarding the road forward in the driving direction, at step S401. The forward road data includes the road type, the forward road shape, the road width and the number of lanes.

Detailed Description Paragraph Right (86):
Most preferably, the decelerating control is initiated in response to an operation by the driver indicating an intention to decelerate, for example releasing the accelerator, depression of the brake pedal and actuation of the blinker. By such control, a shift-change for deceleration is carried out at a suitable timing and at a suitable position, in accordance with the driver's intention.

Detailed Description Paragraph Right (87):
In this embodiment means for calculating a radius of curvature comprises a data memory 12, a current position sensor 13 and a navigation processing unit 11. Navigation processing unit 11 determines specific turning points positioned forward of the current position, based on the current position and the running direction of the vehicle detected by current position sensor 13 and the road information stored in data memory 12. Section calculating means comprises current position sensor 13, data memory 12 and navigation processing unit 11. The turning points to be determined by navigation processing unit 11 include intersections, T-shaped intersections, points where the number of lanes decreases, curves and corners, entrances to the curve or corner, rampways to the freeway, points where the road width narrows, and other points where the vehicle should change a steering angle and thus change its driving direction. Where a radius of the node connecting line exceeds a predetermined value, a beginning and an end of that portion are determined to be an entrance and an exit of the curve or corner. Thus, the section calculating means determines radius variation based on the road information stored in data memory 12 to determine the entrance to the curve, and then calculates a distance (d) from the current position to the determined entrance to the curve.

Detailed Description Paragraph Right (88):
In accordance with three parameters, that is, the vehicle speed, the radius of curvature and the distance (d), navigation processing unit 11 restricts the shiftable range of the transmission stages. More specifically, navigation processing unit 11 determines the upper-limit stage to which the transmission is shiftable during control by the vehicle control device of this embodiment, and outputs a command signal designating the upper-limit speed to A/T ECU 40. A/T ECU 40 controls the transmission so that it is shiftable within a restricted range of speeds, not allowing gear-change to any speed higher than the determined upper-limit stage, based on predetermined transmission maps. For example, even if 4th gear speed should be selected in accordance with the ordinary transmission maps, when the command signal designates 3rd gear speed as the shiftable upper-limit stage, A/T ECU 40 outputs a drive signal for a range of 1st to 3rd gear stages to actuator 42. The upper-limit transmission stage is determined in accordance with control transmission maps shown in FIGS. 10-12 and data tables of the following Tables 1 and 2.

Detailed Description Paragraph Right (93):
The control operation of navigation processing unit 11 will be described hereinbelow with reference to the flowchart of FIG. 13 which illustrates the control operation to be carried out when the vehicle is to enter the curve shown in FIG. 14.

Detailed Description Paragraph Right (94):
First, navigation processing unit 11 acquires the current position of the vehicle 2 and the road information ahead of the current position at step S501. The road information ahead of the current position includes the road classification, the shape of the road ahead, and the coordinate data for the respective nodes N1-Nn positioned ahead of the current position.

Detailed Description Paragraph Right (100):
When the driver's decelerating intention can not be confirmed, the ordinary transmission control is carried out. In such ordinary control, it is possible that navigation processing unit 11 may determine the transmission speed in accordance with the ordinary transmission map. Alternatively, operations of S501-S511 may be effected by A/T ECU 40.

Detailed Description Paragraph Right (102):
In this embodiment, data memory 12, current position sensor 13 and navigation processing unit 11 cooperate with each other to form the road shape inferring means. Navigation processing unit 11 determines a predetermined section ahead of the current position in the vehicle drive direction, based on the current position and the vehicle running direction, both detected by current position sensor 13, and on road information stored in data memory 12. The predetermined section means a section from the current position to another position remote by a predetermined distance (1 km, for example) from the current position in the vehicle drive direction. The distance of the predetermined section may be changed depending on vehicle speed. For example, it may be relatively short when a vehicle is running at a relatively low speed and relatively long during high speed driving. The predetermined section is set along the scheduled drive route.

Detailed Description Paragraph Right (103):
Navigation processing unit 11 also manages first control for determining an average curvature .THETA. of the predetermined section and second control for determining an altitude variation H of the predetermined section.

Detailed Description Paragraph Right (104):
In managing the first control, data memory 12 and navigation processing unit 11 cooperate with each other to constitute average curvature calculating means. Navigation processing unit 11 uses the road data of navigation system 10 to determine if the predetermined section is a winding road and to calculate its average curvature .THETA..

Detailed Description Paragraph Right (109):
In managing the second control, data memory 12 and navigation processing unit 11 cooperate with each other and constitute altitude variation calculating means.

Navigation processing unit 11 uses the altitude data of navigation system 10 to determine a slope variation for a road on which the vehicle is to run.

Detailed Description Paragraph Right (112):
The navigation processing unit 11 determines a shiftable range or the highest transmission stage under control, from the average curvature .THETA. and the vehicle speed. The highest gear speed is determined from the control transmission map shown in FIG. 17. A signal indicating the highest speed is outputted to A/T ECU 40 which controls the automatic transmission within the shiftable range, not allowing operation beyond the highest speed. In the transmission control map of FIG. 17, a control area that prohibits a shift-change beyond 3rd or 4th gear speed becomes wider as the driving speed increases, and with an increase of the average curvature .THETA..

Detailed Description Paragraph Right (116):
As has been described the navigation processing unit 11 of this embodiment determines the highest transmission stage from the average curvature .THETA. and the vehicle speed V, and A/T ECU 40 compares the determined highest transmission stage with a transmission stage selected in accordance with the transmission map to determine a drive signal to be output to actuator 42.

Detailed Description Paragraph Right (117):
Control operation of navigation processing unit 11 will now be described with reference to the flowchart shown in FIG. 19.

Detailed Description Paragraph Right (118):
First, navigation processing unit 11 acquires the current position data of the vehicle 2 and the forward road data, at step S601. Forward road data includes data indicating type of road, shape of the road, and coordinates and altitude of respective nodes plotted forward of the current position.

Detailed Description Paragraph Right (119):
From the road data including the forward road shape and node data forward of the current position which have been obtained at S601, navigation processing unit 11 determines the average curvature .THETA. and the vehicle speed V in accordance with the equations (1) and (2), at step S603. At S603, navigation processing unit 11 functions as a road shape discriminating means which comprises, in this embodiment, average curvature calculating means and altitude variation calculating means.

Detailed Description Paragraph Right (122):
Then, the relationship between the average curvature .THETA. and the vehicle speed V, both obtained at S603, is plotted on the control transmission map shown in FIG. 17, for determining if the upper transmission speed should be restricted, at step S611. When the vehicle speed is relatively high, indicating a point (b) on the map, for example, navigation processing unit 11 determines that the driver has no intention of decelerating the vehicle NO at S611), in which case no upper-limit transmission stage control is carried out and the procedure is returned to the main routine. In this case, the vehicle is driven under the transmission mode (that is the normal mode in FIG. 17) that is now selected by the driver.

Detailed Description Paragraph Right (123):
In another example, where the relationship indicates a point (a) in the map, the transmission is controlled such that it is shiftable within a range of 1st to 3rd speeds. In this case, it is determined that the upper-limit transmission stage control should be carried out (YES at S611) and a command signal indicating the upper-limit transmission stage is output to A/T ECU 40 at step S613. Thus, the transmission speed is shiftable between 1st to 3rd gear speeds. If the current speed is 4th, it is automatically shifted down to 3rd to assist deceleration. Operation at steps S603 and S607-S611 is a function of the control means. Navigation processing unit 11 functioning at step S613 and A/T ECU 40 constitute the actuating means.

Detailed Description Paragraph Right (125):
The above-described control operation may be carried out solely by navigation processing unit 11 or A/T ECU 40. More specifically, in one embodiment, transmission stage selection with reference to the transmission map and upper-limit transmission stage control are carried out by navigation processing unit 11, which outputs a signal

indicating the upper-limit transmission speed to A/T ECU 40. In a modified embodiment, the road information is obtained from navigation system device 10 and operations at S603-S613 are all carried out by the A/T ECU 40.

Detailed Description Paragraph Right (130):
In this embodiment, there is provided a standard acceleration calculating means that calculates standard acceleration of the vehicle in accordance with the vehicle speed, the throttle opening and the gear ratio, in addition to the radius-of-curvature calculating means and the road shape discriminating means of the second and third embodiments. The standard acceleration calculating means comprises data memory 12 and navigation processing unit 11.

Detailed Description Paragraph Right (131):
In this embodiment, navigation processing unit 11 determines a plurality of vehicle speeds V, among which the narrowest range (or the lowest one of the shiftable upper-limit stages of the respective ranges) is selected for actual transmission control.

Detailed Description Paragraph Right (132):
More specifically, the first upper-limit stage is determined by the curvature that has been calculated by the radius-of-curvature calculating means, the second upper-limit stage is determined by the road shape that has been determined by the road shape discriminating means, and the third upper-limit stage is determined by the standard acceleration that has been determined by the standard acceleration calculating means. Navigation processing unit 11 selects the lowest one among the first to third upper-limit stages and outputs a signal indicating the said speed to A/T ECU 40.

Detailed Description Paragraph Right (136):
Control operation of navigation processing unit 11 will now be described with reference to the flow charts of FIGS. 24 to 27. The flowcharts of FIGS. 24 and 25 show the control operation carried out when the vehicle is running through the curve of FIG. 14.

Detailed Description Paragraph Right (137):
First, navigation processing unit 11 acquires the road information from data memory 12 (at step S71). The road information includes coordinate data (X1, Y1)-(Xn, Yn) of nodes N1-Nn (FIG. 14). From such road information, it determines angles at respective nodes between two adjacent segments before and after the nodes, and thus determines the radii of curvature at respective nodes, from which it further determines the continuity of the curve and the curvature variation. Further, it calculates a distance (d) from the current vehicle position to the entrance to the curve, thereby determining the average curvature e and the average altitude variation H in accordance with the equations (1) and (2).

Detailed Description Paragraph Right (142):
Then, the average curvature .THETA. at S71 and the vehicle speed V at S72 are applied to the control transmission map of FIG. 17, whereby navigation processing unit 11 determines if the upper-limit transmission speed control should be carried out in accordance with the transmission control map, at step S905. If the answer is YES at S905, it also determines the shiftable upper transmission stage in accordance with the map of FIG. 17. For example, if the current relationship between the average curvature .THETA. and the vehicle speed V is represented by point (b) in FIG. 17, it is determined that the driver has no intention to slow down, leading to the answer of NO at S905, in which case no control is executed to set the upper-limit transmission stage and the procedure is returned to the main routine of FIG. 24. In this case, the usual automatic transmission control is carried out in the currently available transmission mode (that is the normal mode in the example of FIG. 17).

Detailed Description Paragraph Right (145):
If the answer is NO at S1005, it is then determined if .beta.0>.beta.1 at step S1009. If the answer is YES at S1009, which means that the vehicle is running uphill, a gear speed lower by one than the current gear speed is determined as the upper-limit transmission stage SF3 at S1007. Through execution of steps S1001-S1009 navigation processing unit 11 functions as means for calculating the standard acceleration.

Detailed Description Paragraph Right (151):
The road information to be used in this embodiment includes the average curvature .THETA. and the average slope .left brkt-top.. In this embodiment, data memory 12, current position sensor 13 and navigation processing unit 11 cooperate with each other to detect and analyze the road information, as well as to set a predetermined section. The road shape inferring means includes average slope calculating means, average curvature calculating means, and first and second inferring means.

Detailed Description Paragraph Right (154):
In this embodiment, the average slope .left brkt-top. of the section is determined over a predetermined distance from the road information involved in navigation system device 10.

Detailed Description Paragraph Right (163):
Control operation by navigation processing unit 11 will now be described with reference to the flowcharts of FIGS. 33 and 34.

Detailed Description Paragraph Right (164):
First, a sub-routine for inferring a control section begins at step S1101. This sub-routine follows the flowchart of FIG. 34. Navigation processing unit 11 acquires, at step S1201, the road information including the current position and the altitude data at nodes N1-Nn forward of the current position. From such road information, a section from the current position to a position a predetermined distance forward (1 km, for example) is determined as a tentative section. Then, from the road information are determined the average curvature .THETA. and the average slope .left brkt-top. of the tentative section, at step S1203.

Detailed Description Paragraph Right (177):
A signal indicating the lowest transmission speed at S1121 is output to the A/T ECU 40 for a gear change (down-shift) to the said speed, at step S1123. In a modified embodiment, a signal indicating a lower one of the upper-limit transmission speeds at S1115 and S1117 is supplied to A/T ECU 40, in which case operation through S1119-S1123 is carried out by A/T ECU 40. Alternatively, A/T ECU 40 acquires the road information from the navigation system device 10 to carry out the routines of FIGS. 33 and 34.

Detailed Description Paragraph Right (180):
FIG. 36 shows node positions on the road and FIG. 37 is a transmission control map to be used for determining the upper-limit gear speed from the recommended vehicle speed. Current position sensor 13, data memory 12 and navigation processing unit 11 cooperate with each other as distance calculating means for calculating distances L1-Ln from the current position to the respective nodes.

Detailed Description Paragraph Right (183):
Control operation of navigation processing unit 11 will now be described with reference to the flowchart of FIG. 38.

Detailed Description Paragraph Right (184):
First, at step S1501, navigation processing unit 11 acquires the current position of the vehicle 2 and the forward road data including the road type, the road shape and the coordinate data of the respective nodes N1-Nn forward of the current vehicle position.

Detailed Description Paragraph Right (200):
As has been described, the present invention relates to the vehicle control system that is especially useful in automatic transmission control. In particular, this invention may be used in combination with a navigation system to provide automatic transmission control by utilizing road data and other data stored in the navigation system.

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L13: Entry 1 of 1 File: USPT Aug 3, 1999

DOCUMENT-IDENTIFIER: US 5931886 A
TITLE: Control system for vehicular automatic transmission

Abstract Paragraph Left (1):
A control system for a vehicular automatic transmission which detects running status of the vehicle and includes a shift controller for controlling the gear stage of the automatic transmission in accordance with the detected running status of the vehicle. The control system further includes a memory for prestoring road information for roads to be run by the vehicle, present location detection and running direction detection. A reader reads out the road information for a set route from the present location to a destination, from the memory, on the basis of the detected present location and the destination input. The engine power required for the vehicle to travel the set route is estimated in accordance with the read road information. A shift schedule which minimizes the fuel consumption on the set route is determined by comparing the estimated engine power requirement with a prestored mileage map and the shift control pattern is changed in accordance with the determined shift schedule.

Brief Summary Paragraph Right (6):
Japanese Patent Published No. 58141/1994 discloses a shift control system which monitors the actual detected road circumstances to improve the running safety and the driving comfort by utilizing a navigation system with the shift control so that the control pattern is changed on the basis of the road information obtained from the navigation system in addition to information regarding the running status of the vehicle.

Brief Summary Paragraph Right (11):
Therefore, an object of the present invention is to provide a control system for a vehicular automatic transmission which provides satisfactory running safety and driving comfort and optimum mileage, by applying a navigation system to the shift control of the automatic transmission to set a shift schedule from the present location to the location of a destination, taking into consideration the road circumstances and the mileage.

Brief Summary Paragraph Right (12):
In order to achieve the above-specified object, the present invention provides a control system for a vehicular automatic transmission, comprising: running status detecting means for detecting the running status of the vehicle; and shift control means for controlling the gear stage of the automatic transmission in accordance with the detected running status of the vehicle. The vehicular automatic transmission control system further comprises: memory means for storing beforehand the information for a road to be run by the vehicle; detection means for detecting the present location and running direction of the vehicle; read means for reading out, from the memory means, road information for a determined route from the present location to a destination, on the basis of the signal from the detection means and the location input as a destination; estimation means for estimating driving force required of the vehicle to run the determined route in accordance with the road information read out; shift setting means for setting a shift schedule to minimize the fuel consumption rate on the determined route by comparing the estimated required driving force and a mileage map stored beforehand; and change means for changing a control pattern for the shift control means in accordance with the set shift schedule.

Brief Summary Paragraph Right (13):
The control system of the present invention may further include: operation status detecting means for detecting the operation status of each of various accessories which, in operation, increase the engine load; and operation setting means for setting operation schedules for the accessories during travel on the determined route. The estimation means estimates the driving force required for the vehicle to run the determined route in accordance with the road information coming from the read means and the operation schedules of the accessories. The shift setting means sets the shift schedule to minimize fuel consumption in travel on the determined route by comparing the estimated driving force with a mileage map stored beforehand. The change means changes the shift control pattern in accordance with the shift schedule set by the shift setting means.

Brief Summary Paragraph Right (17):
The control system of the present invention further includes decision means for deciding whether or not the signal coming from the vehicle running status detecting means is within a predetermined range for the vehicle running status, as estimated by the estimation means on the basis of the road information retrieved by the read means. The change means does not change the shift pattern if the decision means decides that the signal is not within the predetermined range.

Detailed Description Paragraph Right (2):
As shown in FIG. 1, a navigation system control unit 1 includes read means 2, estimation means 3, operation setting means 4, calculation means 5, shift setting means 6, decision means 7 and change means 8. To this navigation system control unit 1, are individually connected a GPS (Global Positioning System) 11, a gyro sensor 12, an accessories detecting switch 13, a key input unit 14, memory means 15, a rotation sensor 16 and a vehicle speed sensor 18.

Detailed Description Paragraph Right (3):
The change means 8 of the navigation system control unit 1 is connected to an automatic transmission electronic control unit (A/T ECU) 19 for controlling automatic transmission (A/T) 22. Moreover, the A/T ECU 19 is connected with a throttle opening sensor 17, a vehicle speed sensor 18 and an engine electronic control unit (E/G ECU) 20 for controlling engine (E/G) 21.

Detailed Description Paragraph Right (4):
Upon starting the vehicle, the navigation system control unit 1, the A/T ECU 19 and the E/G ECU 20 are first initialized to operable status.

Detailed Description Paragraph Right (5):
Next, data is input from the various sensors of the navigation system control unit 1, the A/T ECU 19 and the E/G ECU 20.

Detailed Description Paragraph Right (7):
The A/T ECU 19 is connected with the navigation system control unit 1, which retrieves prestored information from the memory means 15 pertaining to the road to be travelled by the vehicle. On the basis of information from the GPS 11 and the gyro sensor 12, the present location and the running direction of the vehicle a re determined. On t he ba sis of these inputs and the input of the destination, road information route determined for travel of the vehicle from the present location to the destination is read out from the memory means 15 by the read means 2 so that the driving force required of the vehicle along the travelled (determined) route is estimated by the estimation means 3 in accordance with the read road information.

Detailed Description Paragraph Right (9):
The navigation system control unit 1 also receives input from the accessories detecting switch ("monitoring means") 13 which monitors the operating status of those accessories which increase the engine load in operation. The operation setting means 4 sets operation schedules for the accessories during travel along the determined route in accordance with the detected operation status of the accessories and the road information retrieved by the read means 2. The estimation means 3 estimates the driving force required for the vehicle in accordance with the road information received from the read means 2 and the operation schedules of the accessories. The shift setting means 6 sets the shift schedule minimizing the fuel consumption rate for

the determined route by comparing the estimated driving force and the mileage map stored beforehand. The change means 8 changes the control pattern in the A/T ECU 19 in accordance with the shift schedule which is set by the shift setting means 6.

Detailed Description Paragraph Right (13):
The decision means 7 decides whether or not the signal coming from the vehicle running status detecting means is within a predetermined range for the vehicle running status, as estimated by the estimation means 3 on the basis of the road information coming from the read means 2. The change means 8 does not change the shift pattern if the decision means 7 decides that the signal is not within the predetermined range.

Detailed Description Paragraph Right (17):
FIG. 9 shows a mileage map, to which are added the navigation information (e.g., the friction coefficient and inclination of the road per step S5 in FIG. 2.). The shift schedule of FIG. 9 is based upon the relationship between engine RPM and the driving torque of FIG. 8, and the vehicle information (e.g., the load attributable to operation of the air conditioner and the number of occupants) at Step S5. Specifically, in FIG. 8 curve "a" indicates a constant driving horsepower A (under a light load), and curve b indicates the case (under a heavy load) in which the load of operation of the air conditioner or the like is added to the constant driving horsepower A. In FIG. 9, the optimum gear under light ("low") load is seen to be the 3rd, that is, the optimum gear for producing the constant driving horsepower A is the 3rd gear. The optimum gear for heavy load is the 2nd, i.e. the optimum gear for the sum of a constant driving horsepower and the load imposed by operation of the air conditioner.

Detailed Description Paragraph Right (18):
FIG. 9 also illustrates use of the navigation system. The "timing for the shift" and "what gear is to be selected" are determined on the basis of the road information (e.g., the inclination information) from the starting point to the destination so as to minimize the fuel consumption rate as indicated by the fuel map, and the shifting is effected according to the determined shift timing and selected gear.

Detailed Description Paragraph Right (19):
When the simulation of fuel consumption rate results in a decision that no shift can improve the mileage, the command of "no shift" is sent from the navigation system to the A/T ECU 19 and no shift is executed.

Detailed Description Paragraph Right (20):
Thus, a gear stage of highly efficient fuel consumption can be automatically set by the A/T ECU 19 on the basis of the navigation information and the vehicle information.

Detailed Description Paragraph Right (30):
On the basis of the road information, moreover, the optimum gear speeds are set. In other words, shifting can be finely controlled ("fine-tuned") on the basis of the navigation information and the vehicle information, both of which affect the mileage.

Detailed Description Paragraph Right (33):
In accordance with the present invention, the driving force required for travel on a set route, from the present location to the destination, is estimated according to the road information coming from the read means. Specifically, the driving force required for coping with changing circumstances on the road to be encountered by the vehicle, such as hills and flat runs, is estimated on the basis of road information for the set route, as obtained from the navigation system, so that the required driving energy can be matched beforehand with the anticipated road and traffic conditions.

Detailed Description Paragraph Type 1 (2):
(2) The road information is acquired (at Step S2) from the memory means 15 by the navigation system control unit 1.

Detailed Description Paragraph Type 1 (31):
(3) By using the navigation system, information for the friction coefficient, vehicle movement and inclination of the road are converted into values for driving load.

Detailed Description Paragraph Type 1 (32):
(4) On the basis of the foregoing items of information (1) to (3) and information pertaining to the route from the starting point to the destination obtained by the navigation system, the gear simulation for optimizing the fuel consumption rate is executed.